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POTENTIAL CONSEQUENCES OF A CO_2 AVIATION TAX IN MEXICO ON THE DEMAND FOR TOURISM

Luis Miguel Galindo, Allan Beltran[*] and Karina Caballero[†]

Abstract: There is limited evidence on the potential consequences of the implementation of a CO_2 aviation tax in developing countries. In this paper we analyze the potential impact of a CO_2 aviation tax on the inbound tourism demand from the United States, Canada and Europe to Mexico. The methodology consists of a panel cointegration estimation of the demand for international tourism to Mexico. Unlike previous studies we analyze the potential effect of the tax on both tourism expenditure and the number of airplane arrivals. The results indicate an income elasticity of 1.9 for tourism expenditure and 2.9 for the number of airplane tourist. The price elasticities of airplane tourism expenditure and the number of airplane tourists are -0.94 and -0.39, respectively. The difference in price elasticity between tourism expenditure and number of tourists suggest that a CO_2 aviation tax in Mexico would lead to a larger adjustment in total expenditure rather than in trip decisions. The implementation of such tax is therefore consistent with a continuous growth of the demand for tourism. Furthermore, the tax has the potential to generate additional fiscal revenue for 163 - 480 million dollars. The price elasticity of the competitive destination highlights the importance of considering a regional agreement for the implementation of an international CO_2 aviation tax.

JEL: L93, Q54, Z38

Keywords: International tourism; Carbon dioxide emissions; Tax; Aviation; Mexico.

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[*] Corresponding author. E-mail: a.i.beltran-hernandez@lse.ac.uk..

[†] The first author is member of the Sustainable Development and Urban Settlements Division of the Economic Commission for Latin America and the Caribbean (ECLAC). The second author is Postdoctoral Fellow in Environmental Economics at the London School of Economics and an Associate at the Grantham Research Institute on Climate Change and the Environment. The third author is Lecturer at the Faculty of Economics at UNAM. Luis Miguel Galindo is also professor at the Faculty of Economics at UNAM and affiliate professor at CIDE. We appreciate the comments of Chris Taylor, Andrei Marcu, Wijnand Stoefs and Roberto Cabral. We appreciate the research assistance of Maximiliano Alvarez. The usual disclaimer applies. The opinions in this article are the responsibility of the authors only and do not represent institutional positions.

I. INTRODUCTION

Foreign airline tourism has several positive effects on the Mexican economy but it also generates several negative environmental externalities such as carbon dioxide (CO_2) emissions derived from airplane flights (Pearson, 1985). Aviation CO_2 emissions represent just 2% of total CO_2 emissions in 2014[3] but they are growing fast and there are very few options to control them in the short run[4]. In this context, there is an increasing interest on the potential effect of a CO_2 tax on the aviation sector (Pearce and Pearce, 2000; Wit et al., 2005).

There are already several environmental taxes on airplane traffic in some European Countries and there are also several analyses considering the inclusion of aviation emissions under the framework of the European Trading System (ETS) for carbon dioxide (Wit et al., 2002, 2005). However, these CO_2 taxes have been analyzed mainly in developed countries and there are few studies for developing countries. Therefore, the main objective of this article is to analyze the potential consequence of a CO_2 tax on flights from the United States, Canada and Europe on airplane tourism expenditure and the number of airplane tourist arrivals to Mexico. The article is divided into four sections. The first section is, obviously, the introduction, the second section presents the general framework and the third section discusses the literature review. The fourth section shows the results of the econometric analysis of the tourism demand for Mexico and the effect of a carbon tax on tourism demand. The fifth section discusses the policy implications of the analysis and concludes.

II. GENERAL FRAMEWORK

The global aviation sector has historically been one of the most rapidly growing economic sectors. According to figures from the International Civil Aviation Organization (ICAO) the global number of air passenger increased at an annual rate of 7% during the period 1990 - 2014 (ICAO, 2016). In 2014 there were a total of 3.2 billion air passengers globally, this figure is expected to reach 7.2 billion in 2035 (IATA, 2016). The expected growth in the demand for air travel implies a rise in the number of flight operations and therefore in the total volume of aviation CO_2 emissions. During

[3] Air Transport Action Group (2016). www.atag.org.
[4] For example, the new Airbus is expected to be in use for the next 30 years (Bows and Anderson, 2007).

the period 1990 – 2012 international aviation CO_2 emissions grew by over 75% and they are projected to grow up to 300% by 2050 unless action is taken (ICAO, 2016).

In Mexico, international tourism is very dynamic and airline tourism is one of its main components. For example, in 2014 the total number of international tourists[5] coming to Mexico was 16 million; this influx of tourist generated a total expenditure of about 12.9 billion dollars (2011 prices). Both variables show an annual average growth rate of 3.9% and 3.3%, respectively, for the period 1980-2014. Out of the total number of international tourists traveling to Mexico in 2014, 84% (13.5 million) arrived by plane and they accounted for 94% (12.1 billion dollars) of the total international tourism expenditure in the country. The average growth rate of international airplane tourism and airplane tourism expenditure in Mexico for the period 1980-2014 was 5% and 3.9%, respectively[6] (table 1) (BANXICO, 2016; SECTUR, 2014). This growth is expected to continue for the foreseeable future.

Table 1. Basic statistics of international tourism to Mexico

	International Tourism to Mexico		
	Total	**Airplane**	**Road**
Number of tourists (2014) (millions)	16.0	13.5	2.5
(*share in parenthesis*)	(100%)	(84%)	(16%)
Growth rate:			
1980 – 1990	4.4	5.7	2.2
1991 – 2000	5.2	6.3	2.3
2001 – 2010	2.3	2.9	0.3
2010 – 2014	3.1	4.0	-1.1
Average 1980 – 2014	3.9	5.0	1.2
Tourism expenditure (2015) (million 2011 USD)	$12,925	$12,156	$769
(*share in parenthesis*)	(100%)	(94%)	(6%)
Growth rate:			
1980 – 1990	5.2	5.7	3.1
1991 – 2000	0.6	1.5	-4.5
2001 – 2010	3.2	3.5	0.6
2010 – 2014	4.5	4.8	-0.2
Average 1980 – 2014	3.3	3.9	-0.3

Source: BANXICO (2016). Account of international travelers.
Note: Cross-border tourism is excluded.

[5] Airline tourism expenditure from United States, Canada and Europe represent 74%, 6% and 6% of total airline tourism expenditure in Mexico (BANXICO, 2016).
[6] In 2014 the average expenditure of a tourist from the United States, Canada and Europe in Mexico was about 1,176 dollars per person (2011 prices) (INEGI, 2015).

It is estimated that by 2010 65% of total aviation CO_2 emissions in Mexico corresponded to international flights (Herrera and Vales 2013). Under the Paris Agreement (2015) Mexico is committed to a 22% unconditional reduction of greenhouse gases (GHG). Given the urgency of addressing the issues of climate change and the relevance of international tourism for the Mexican economy it is important to explore the economic impact of policies that can contribute to make international traveling a more sustainable activity. In this paper we analyze the effect of a CO_2 aviation tax on the demand of tourism in Mexico.

III. LITERATURE REVIEW

The consequences of a CO_2 tax on airline tourism are closely related with the analysis of the price elasticity of tourism expenditure or number of tourist arrivals (Michaelis, 1997). This analysis assumes that tourism expenditure satisfies the weak separability condition and, therefore, there is a multistage budgeting process (Deaton and Muellbauer, 1980). Thus, the consumer, initially, decides the expenditure allocated to tourism and afterwards decides the allocation for different tourism products. In this sense, tourists consume a bundle of goods and services while traveling and, therefore, a CO_2 tax might affect the total tourism expenditure or the number of visitors.

Demand equations for tourism expenditure or the number of visitors are usually specified as follows (Song and Witt, 2000; Witt and Witt, 1995):

(1) $$te_{it} = \beta_{0t} + \beta_{1t}y_{it} + \beta_{2t}p_{it} + \beta_{3t}pa_{it} + \beta_{4t}ot_{it} + u_{it}$$

Where TE_{it} represents tourism expenditure in real terms or the number of tourist arrivals from country i to the selected destination, Y_{it} is income or income per capita of the country of origin, P_{it} is the price index costs in the tourist destination[7], PA_{it} represents the price index of a competitive destination, and OT_{it} represents other variables such as habit persistence, advertisement, age, time of travel, characteristics of the destination and tourist infrastructure,

[7] The distinction between the price effect and the exchange rate effect considers that the responses are different because consumers are more aware of the exchange rate than of local prices (Crouch and Ritchie, 2005).

education level, language, homicide rates or political stability. Small letters indicate the natural logarithm of the variables in the entire document.

There are already a large number of studies on the demand for tourism with different estimation techniques, methodologies, time periods, countries and variables. In general, the evidence shows that tourism expenditure is influenced by the evolution of income and price but that the specific responses are heterogeneous when considering, country of origin and destination, type of expenditure, time of traveling or purpose of the trip (Song et al., 2009; Battersby and Oczkowski, 2001).

Table 2 summarizes the evidence from different large reviews of the literature or meta-analyses on the elasticities of international tourism demand. The average income elasticity of the meta-analyses is 2.5 but the variability of the results is rather large. For example, some of the meta-analyses identify an average income elasticity between 1 and 2.5 (Peng, et al. 2015, Crouch, 1996, Wit and Wit, 1995, Song et al., 2010; Song and Wit, 2003).

The average own-price elasticity of tourism demand[8] of the meta-analyses is -0.7. However, the evidence on the price elasticity of tourism expenditure can be classified for public policy purposes into two groups. In the first group, there are price elasticities of the demand for tourism larger, in absolute terms, than -1 and therefore the tax impact on tourism expenditure is significant (Peng et al., 2015, Brons et al., 2002, Oum et al., 1990; Battersby and Oczkowski, 2001). The second group indicates that tourism activities are price inelastic considering the presence of asymmetric information and inevitable expenses. Travelers do not know the real prices of the tourist destination but it is inevitable that they consume once they arrive there[9] (Crouch, 1996, Peng et al., 2015, Witt and Witt, 1995, Song et al., 2010, Wohlgemuth, 1997; Melville, 1998). There is considerable less evidence on the price elasticity of competitive destinations and it is very heterogeneous (Song, et al., 2009). For example, Gonzalez and Moral (1995) find a price elasticity of -0.65 for competitive destinations, Witt and Witt (1995) estimate an average cross-price elasticity of 1.3 and Seetanah

[8] In most cases the cost of tourism is defined as the price index at the destination country with respect to the country of origin.
[9] Also, ICAO (1985) assumes a price elasticity for long flights of -0.8.

et al. (2010) find relative price elasticity between 0.07 and 0.26 for alternative destinations. Under these conditions a national tourism tax might generate some sort of tourism leakages (Aguiló et al., 2005). Finally, the specific evidence for Latin America and Mexico suggests an average income elasticity close to 2 and a very heterogeneous price elasticity, between 0 and -2.0 (Jud and Joseph, 1974, Bridal et al., 2008, Wit et al., 2005, Stronge and Redman, 1982).

There is also evidence on price elasticities of transportation costs on travel demand. For example, Jud and Joseph (1974) estimate the transport price elasticity of tourism expenditure from United States to Latin America between -1.6 and -2.0. Also, Witt and Witt (1995) estimate transport price elasticity between -0.04 and -4.3 with a median value of -0.5 and a median price elasticity of -0.7 in destination costs. Sobieralski (2012) estimates, for the United States, a long run price elasticity of airplane fuel demand between -0.13 and -0.30 for aggregate series and -0.04 and -0.31 for panel data. However, it is common that transportation costs are not included as an independent variable in the econometric specification due to potential multicollinearity with income and other costs and because travel costs data are considered not to be very reliable (Song et al., 2009). Also, there is evidence that changes in tourism prices derive on several adjustment processes on the demand for tourism. For example, there is a negative cross price elasticity among different items of tourism expenditure suggesting that all these items are complementary (Divisekera, 2010). Additionally, Brons, et al. (2002) consider that airline ticket price elasticity generates complex adjustment processes, such as the substitution of Airplane Company or mode of transport. This implies that the real reduction in traveling and in CO_2 emissions as the consequence of a new tax is potentially less than originally estimated.

Table 2. Tourism demand elasticities: Summary results from meta-analysis studies

Author	Income elasticity			Own-Price elasticity		Cross-Price elasticity	
	Mean[1]	Range[2]		Mean[1]	Range[2]	Mean[1]	Range[2]
Oum et al. (1990)				-1.4	-0.4 - -4.5		
Witt and Witt (1995)	2.4	6.6 – 0.4	Own-price	-0.7	-0.04 - -1.5	1.1	0.1 – 3.3
			Travel cost	-0.5	-0.04 - -4.3	1.6	0.6 – 6.3
			Exchange rate	1.8	2.2 – 0.6		
Crouch (1995)	2.2	4.1 – 0.3	Own-price	-0.9	-0.2 - -1.7		
			Travel cost	-1.2	0.1 - -1.9		
			Exchange rate	-0.9	0.2 - -1.6		
Crouch (1996)	2.2	5.0 – 0.5		-0.9	0.9 - -3.4		
Lim (1999)	3.2	4.1 – 2.2	Own-price	-0.7	-0.4 - -1.1		
			Travel cost	-0.9	-0.2 - -2.0		
Brons et al. (2002)				-1.1	0.2 - -3.2		
Peng et al. (2015)	2.5	6.4 – 1.0		-1.3	-0.3 - -1.7		
Mean elasticity	**2.5**			**-0.7**		**1.3**	

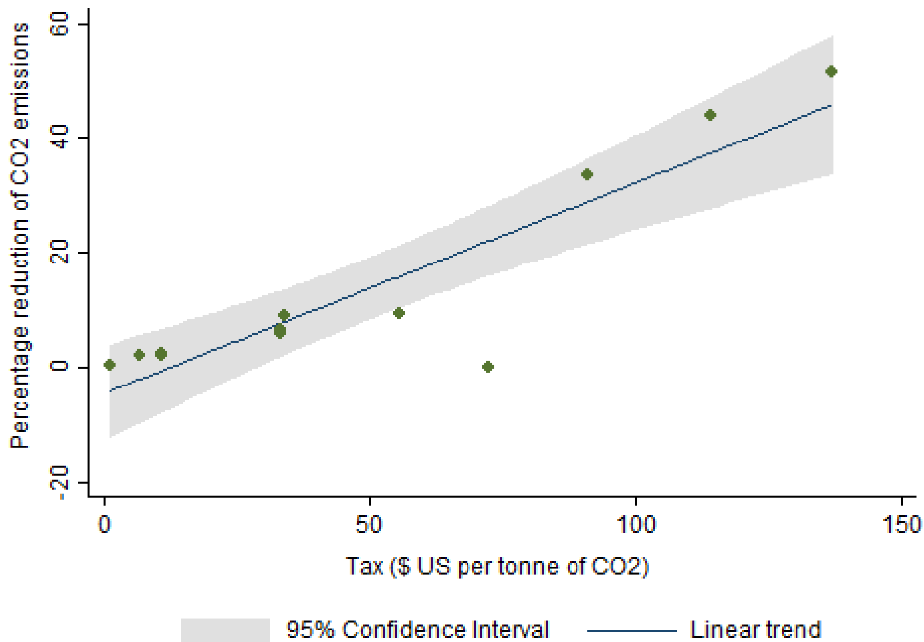
Note: [1] Mean, corrected mean or average, depending on the measures reported in the individual studies.
[2] Refers to the minimum and maximum values of the meta-sample.

There are several studies on the consequences of a carbon tax on CO_2 emissions under the assumption that the tax is passed on to the consumer. Figure 2 summarizes the evidence from these studies. All taxes are converted to US dollars per tonne of CO_2 and emission reductions are expressed as relative to the total emissions of the aviation sector. For example, Wit et al. (2002) argue that a tax between 10 and 50 euros per tonne of CO_2 increases[10] the price of airline tickets in the range of 10 to 20 euros. This would lead to a reduction of CO_2 emissions of -1% and -5%[11], respectively. Wit et al. (2005), considering a CO_2 trading system, estimate that a tax between 10 and 30 euros per tonne of carbon will lead to a rise in airline ticket prices of 0.2 and 2.9 euros using price elasticities between 0 and -1. Michaelis (1997) estimates that a tax between 5 and 125 dollars per ton of CO_2 increases airline ticket prices in the range of 2% to 50% and reduce the demand for air travel between 4.4 – 13.3% with price elasticities of -0.7 and -2.1. Olsthoorn (2001) argues that a tax of $1500 per tonne of CO_2 might reduce aviation emissions by 90%. FitzGerald and Tol (2007) and Mayor and Tol (2007) argue, imposing a price elasticity of -0.45, that a carbon

[10] This implies a price increase between 2% and 6% in holiday packages (Wit et al., 2002).
[11] Wit et al. (2002) argue that a €50/t CO2 carbon tax is equivalent to €9 charge per round trip. These authors use price elasticities of the AERO model developed by the Dutch Civil Aviation Administration which range between -0.7 and -0.9 depending on the region of origin.

tax on British flights will have a small impact on the demand. Therefore, a global carbon tax of 1000 dollars per ton would reduce travel flights by only 0.8% and CO_2 emissions by 0.9% (Tol, 2007). Similarly, Pearce and Pearce (2000) suggest that a flight London-San Francisco with a pollution tax equal to the shadow price of aircraft pollutants (including CO_2) implied a carbon tax of 13.54 pounds; that is, a tax of 1.9% on the ticket price. All this evidence suggests that the impact of a carbon tax on the price of the airline ticket is limited. Only a very high tax might seriously influence CO_2 emissions (Wit et al., 2005; Olsthoorn, 2001).

Figure 2. Literature review: Carbon tax and CO_2 reduction in the aviation sector



Note: The percentage reduction of CO_2 emissions is relative to the total CO_2 emissions of the aviation sector in the relevant market for each study. All taxes have been converted to US dollars per tonne of CO_2. Results from Michaelis (1997) are included assuming that the estimated reduction in air traffic is proportional to the reduction in CO_2 emissions.

IV. EMPIRICAL RESULTS

Our empirical analysis is based on the inbound tourism demand to Mexico from the United States, Canada and Europe. Equation (2) shows the econometric specification for the demand of airplane tourism. The econometric estimations are based on a panel data with an unbalanced structure. The data set consists of annual information for Mexico for the period 1980-2014 for tourists from the

United States and Canada, and 1980-2003 for tourists from Europe. The different periods are a consequence of the availability of the data. The dependent variable considers two common definitions of tourism demand that are available in the literature, namely (i) airplane total tourist expenditures by visitors from country of origin i in Mexico (TE_{it}), and (ii) total number of airplane tourists from country i to Mexico (TV_{it}) (Peng et al., 2015; Witt and Witt, 1995).

(2) $$te_{it} = \beta_{0t} + \beta_{1t}y_{it} + \beta_{2t}p_{it} + \beta_{3t}pa_{it} + u_{it}$$

Where TE_{it} represents airplane tourism expenditure in real terms or airplane tourist arrivals from country i to Mexico; Y_{it} is the income per capita measured as the GDP per capita at the country of origin i; P_{it} is the tourism price index constructed as the general price index in Mexico relative to the price index at the country of origin i (2011=100), multiplied by the corresponding nominal exchange rate. This price index is considered a reasonable alternative, however, it also generates several controversies as it does not necessary represent the price that the consumer pays[12] (Song and Witt, 2000). Colombia is considered as the relevant competitive destination. Our definition of the price index at the alternative destination, PA_{it}, follows that of authors such as Song et al. (2003), Seetanah et al. (2010) or Kusni et al. (2013) where the price index of the competitive destination (Colombia) is divided by the price index at the country of origin i (2011=100), multiplied by the corresponding nominal exchange rate[13]. The variables measured in monetary terms are expressed in US dollars and deflated using the general price index (2011=100) of the corresponding country.

The data set is collected from official sources. Airplane tourist expenditure and airplane tourist arrivals are from the Mexican Ministry of Tourism (SECTUR) accessed via the National Institute of Statistics and Geography (INEGI, 2015). The nominal exchange rates of the Mexican peso to the currency of country i are from the Mexican Central Bank (BANXICO). The GDP per capita of the countries of origin is collected from the official economics statistics bureau of the corresponding countries. Data on consumer price indices and nominal exchange rates are from the

[12] However, the use of this price index is common (Witt and Witt, 1995).
[13] This differs from the substitute price index used by authors such as Song et al. (2000) and Kulendran and Witt (2001) where the price index at the alternative destination is defined as the price in the destination relative to that in the competing destinations.

official website of the Central Bank in each country. Unfortunately, the information of tourism costs is not clear-cut. The data on the real airfare, for example, is difficult to obtain. It was, therefore, not possible to estimate the specific price elasticity for the demand of airline tickets. The data on inbound tourism to Mexico correspond to visitors staying for more than 24 hours in the country; hence cross-border tourism is excluded[14]. Table 3 summarizes the basic statistics of the database.

Table 3. Summary statistics

Descriptive Statistic	Variable [1]				
	TE_{it}	TV_{it}	Y_{it}	P_{it}	PA_{it}
Mean	2,491	3,014	34,755	106.5	91.4
Median	627	490	34,026	103.2	87.9
Maximum	9,553	12,742	50,535	167.6	173.2
Minimum	157	86	21,139	62.7	54.4
Std. Dev.	2,847	3,866	7,602	22.5	24.9
Observations	94	94	94	94	94
Cross section	3	3	3	3	3
	Δte_{it}	Δtv_{it}	Δy_{it}	Δp_{it}	Δpa_{it}
Mean	0.026	0.039	0.015	-0.004	-0.007
Median	0.019	0.039	0.017	0.012	-0.004
Maximum	0.802	0.763	0.061	0.289	0.212
Minimum	-0.574	-0.625	-0.048	-0.531	-0.428
Std. Dev.	0.214	0.228	0.019	0.151	0.107
Observations	91	91	91	91	91
Cross section	3	3	3	3	3

Note: [1] i = United States, Canada and Europe; TE_{it} is measured in million 2011 US dollars; TV_{it} is the number of airplane tourists to Mexico expressed in thousands of people; P_{it} and PA_{it} are the relative price indices at the destination and competitive destination countries, respectively (2011=100). Letters in small cases denote the natural logarithm of the series.
Source: Based on official statistics as described in the text.

The panel unit root tests, summarized in table 4, indicate that tourism expenditure, number of tourists, income per capita by country of origin, the relative tourism prices of Mexico and the alternative price index destination are non-stationary series[15].

[14] For visitors to boarder cities a minimum stay of 72 hours is required to be considered as tourists.
[15] Although there are some exceptions in which the null of nonstationarity can be rejected for the variables in levels, differencing the variables results in a consistent rejection of the null. Therefore the panel unit root tests tend to confirm the hypothesis that all the variables are nonstationary $I(1)$ processes.

Table 4. Panel unit root tests

Variable	LLC			IPS		ADF-Fisher[1]		
	A	B	C	A	B	A	B	C
Dependent variables								
te_{it}	-0.782 (3)	-1.291 (1)	1.645 (1)	-1.581 (3)	-0.860 (1)	11.127 (3)	7.548 (1)	1.115 (1)
Δte_{it}	-6.133 (0)*	-7.184 (0)*	-8.732 (0)*	-6.329 (0)*	-7.375 (0)*	40.215 (0)*	52.167 (0)*	70.134 (0)*
tv_{it}	-2.069 (2)*	-0.704 (1)	2.905 (1)	-2.275 (2)*	0.782 (1)	14.949 (2)*	2.206 (1)	0.711 (1)
Δtv_{it}	-10.947 (0)*	-11.745 (0)*	-10.831 (0)*	-9.391 (0)*	-10.289 (0)*	68.021 (0)*	75.918 (0)*	100.72 (0)*
Independent variables								
y_{it}	1.428 (1)	-2.124 (1)*	4.152 (1)	1.719 (1)	0.335 (1)	3.018 (1)	3.806 (1)	0.035 (1)
Δy_{it}	-5.853 (0)*	-5.720 (0)*	-4.586 (0)*	-3.942 (0)*	-4.499 (0)*	24.534 (0)*	30.309 (0)*	29.278 (0)*
p_{it}	-1.373 (0)	-1.733 (0)*	-0.441 (0)	-1.344 (0)	-1.982 (0)*	9.939 (0)	13.123 (0)*	3.222 (0)
Δp_{it}	-7.644 (1)*	-8.608 (1)*	-9.288 (0)*	-7.065 (1)*	-7.937 (1)*	47.472 (1)*	59.126 (1)*	78.705 (0)*
pa_{it}	-1.112 (4)	-1.760 (3)*	-0.704 (1)	-1.510 (4)	-0.741 (3)	8.116 (4)	17.738 (3)*	3.868 (1)
Δpa_{it}	-2.678 (0)*	-3.268 (0)*	-6.034 (0)*	-3.213 (0)*	-3.872 (0)*	20.042 (0)*	25.684 (0)*	42.365 (0)*

Note. Unbalanced panel. Period 1980-2014 for *i* =United States and Canada, and 1980-2003 for *i* =Europe. The values in the table refer to the relevant statistic of the corresponding panel test on the natural logarithm of the series. Values in parenthesis correspond to the optimal number of lags based on Schwarz information criterion. All tests assume the existence of a unit root under the null.

(*) indicates a rejection of the null hypothesis at the 5% level of significance. Model A: individual intercept and trend. Model B: individual intercept. Model C: no intercept and no trend.

[1] Refers to the ADF-Fisher Chi-square statistic.

The analysis of a long-run relationship in the demand of tourism to Mexico (equation (2)) considers three different panel cointegrations tests: the Engle and Granger (1987) type residual based tests by Kao (1999) and Pedroni (1999, 2004), and the Fisher (1932) type test using Johansen's (1988, 1995) cointegration test methodology by Maddala and Wu (1999). Table 5 summarizes the results for these tests. The tests consider all variables included in the tourism demand specification in equation (2) and two separate panel cointegration tests for the two dependent variables that we consider in the analysis, airplane tourism expenditure and number of airplane tourists.

Table 5. Panel cointegration tests

Panel Cointegration Test	Dependent variable							
	Tourism expenditure (te_{it})				Number of tourists (tv_{it})			
Pedroni (1999, 2004)								
	Statistic	Prob.			Statistic	Prob.		
Within group								
Panel v	0.349	0.363			-0.346	0.635		
Panel rho	-0.019	0.492			-1.872**	0.031		
Panel PP	-0.916	0.179			-2.742***	0.003		
Panel ADF	-2.983***	0.001			-2.721***	0.003		
Between group								
Group rho	0.855	0.804			-0.708	0.239		
Group PP	-0.483	0.315			-2.232**	0.013		
Group ADF	-2.702***	0.003			-2.195**	0.014		
Kao (1999)								
	Statistic	Prob.			Statistic	Prob.		
ADF Statistic	-4.188***	0.000			-3.524***	0.000		
Maddala and Wu (1999)								
H_0	λ-Trace rank test	Prob.	λ-Max rank test	Prob.	λ-Trace rank test	Prob.	λ-Max rank test	Prob.
None	26.11***	0.000	16.68***	0.010	26.34***	0.000	19.29***	0.004
At most 1	12.83**	0.046	7.77	0.255	12.46*	0.052	6.95	0.326
At most 2	8.32	0.215	6.43	0.377	8.38	0.211	8.43	0.208
At most 3	5.86	0.439	5.86	0.439	3.42	0.754	3.42	0.754

Note. The values in the table refer to the relevant statistic of the corresponding panel cointegration test. (***), (**) and (*) indicate rejection of the null hypothesis at the 1%, 5% and 10% significance level, respectively. Pedroni (1999, 2004) and Kao (1999) test the null hypothesis of no cointegration. The null hypothesis of Maddala and Wu (1999) is as specified in the table. Unbalanced panel. Period 1980-2014 for *i* =United States and Canada, and 1980-2003 for *i* =Europe. All variables correspond to the natural logarithm of the series. All tests are performed on the model estimated with intercept, but no trend.

Pedroni's (1999) panel cointegration test indicates that, for the model using the number of airplane tourists (tv_{it}) as the dependent variable, the null of no cointegration can be rejected at the 5% significance level in most of the cases. However, with airplane tourism expenditure (te_{it}) as the dependent variable, the results are inconclusive as it is only possible to reject the null based on the panel and group version of the ADF-statistic. Nonetheless, Pedroni (1999) shows that the panel ADF and group ADF statistics have the best small-sample properties of the seven test statistics, and thus, provide the strongest single evidence of cointegration. Furthermore, the results using the approach by Kao (1999) are unambiguous in the sense that they reject the null of no cointegration at the 1% significance level for the two models in table 5.

Cointegration tests by Pedroni (1999) and Kao (1999) are residual based and do not allow for the possibility of multiple cointegrating vectors. The Johansen's Fisher panel cointegration test by Maddala and Wu (1999) addresses this issue using likelihood ratio-type statistics to test the cointegrating rank of a system in heterogeneous panels. Table 5 shows the results of both the trace (λ-Trace) and maximum eigenvalue (λ-Max) statistics. For the two systems represented in table 5, using te_{it} or tv_{it}, the trace statistic indicates the existence of two cointegrating vectors at the 5% and 10% level of significance, respectively, whereas the maximum eigenvalue test suggests the existence of only one cointegrating relationship at the 1% level of significance. Lütkepohl et al. (2001) argue that the trace statistic has a superior power performance however their analysis is in a bivariate setting. More recently Spiru and Qin (2016) suggest that in a multivariate framework like the one we analyze in this paper the maximum eigenvalue test has more power. We therefore follow Spiru and Qin (2016) and conclude the existence of one cointegrating relationship for each set of variables in table 5 based on the maximum eigenvalue statistic. Altogether, the panel cointegration tests in table 5 provide strong evidence of cointegration considering airplane tourism expenditure or number of airplane tourists.

Table 6 shows the estimated long-run parameters of equation (2) using both fully modified OLS (FMOLS) and dynamic OLS (DOLS) (Pedroni, 2000 and 2001, Kao and Chiang, 2000 and Mark and Sul, 2003). We report the coefficients for the panel regressions and the individual cross-sections. For both models we use the group-mean panel estimators proposed by Pedroni (2001) which accounts for the potential parameter heterogeneity present in the fixed effects among different cross-section units of the panel. Pedroni (2001) shows that this estimator behaves well under heterogeneity prevalent in the dynamics associated with panels that are composed of aggregate national data. This procedure also allows us to recover coefficients for individual members of the panel as shown in table 6. Column (1) shows the long-run parameters of the cointegration relationship of the demand of tourism to Mexico normalized for airplane tourism expenditure (te_{it}) and for the number of airplane tourists (tv_{it}). Both estimators, FMOLS and DOLS, yield similar results with slightly greater coefficients for the equations using DOLS. Due to the small sample properties of the DOLS estimator, this represents our preferred specification for the interpretation of results (Pedroni, 2000; Kao and Chiang, 2000). The results indicate that airplane tourism expenditure has a positive income per capita elasticity of 1.86 and a negative own-price elasticity of -0.94. The coefficient on the price index of the competitive destination has the expected sign, with a cross-price elasticity of 0.36. This positive coefficient indicates that international tourism to Mexico considers Colombia as a possible substitute destination. Therefore, the reduction in the relative price of tourism to Colombia, with respect to the country of origin, derives in a reduction of international tourism to Mexico.

Table 6. Demand of tourism to Mexico: Heterogeneous panel cointegration regressions using FMOLS and DOLS

Model	(1) Dependent variable: te_{it}			(2) Dependent variable: tv_{it}		
	y_{it}	p_{it}	pa_{it}	y_{it}	p_{it}	pa_{it}
FMOLS						
Panel	1.873***	-0.899***	0.218**	2.882***	-0.244*	0.207*
	(0.192)	(0.118)	(0.106)	(0.210)	(0.133)	(0.118)
United States	1.707***	-0.625***	-0.015	2.288***	0.006	0.111
	(0.087)	(0.097)	(0.061)	(0.117)	(0.130)	(0.082)
Canada	2.421***	-1.573***	0.267*	3.500***	-0.649**	0.209
	(0.241)	(0.186)	(0.160)	(0.311)	(0.241)	(0.214)
Europe	1.492***	-0.499*	0.402*	2.858***	-0.091	0.301
	(0.517)	(0.284)	(0.253)	(0.536)	(0.294)	(0.273)
DOLS						
Panel [2,1] [1]	1.861***	-0.940***	0.346***	2.887***	-0.386**	0.309**
	(0.189)	(0.146)	(0.118)	(0.244)	(0.189)	(0.138)
United States	1.494***	-0.550***	-0.001	2.142***	0.103	0.134*
	(0.096)	(0.131)	(0.059)	(0.103)	(0.188)	(0.075)
Canada	2.297***	-1.717***	0.766***	3.609***	-0.935***	0.365*
	(0.259)	(0.220)	(0.157)	(0.285)	(0.225)	(0.214)
Europe	1.791***	-0.552	0.274	2.993***	-0.179	0.312
	(0.496)	(0.354)	(0.264)	(0.674)	(0.495)	(0.346)

Note. Standard errors in parenthesis. (***), (**) and (*) indicates rejection of the null hypothesis at the 1%, 5% and 10% significance level, respectively. Unbalanced panel. Period 1980-2014 for *i* =United States and Canada, and 1980-2003 for *i* =Europe. All variables correspond to the natural logarithm of the series.

[1] The numbers in brackets represent the optimal number of lags and leads, respectively, included in the DOLS estimation based on the Schwarz information criterion. See Kejriwal and Perron (2008) on the good performance of the Schwarz criterion for lags and leads selection in DOLS regression.

The results in column (2) indicate that the number of tourists has a positive income per capita elasticity with a coefficient greater than one (2.89), a negative own-price elasticity (-0.39) and a positive cross-price elasticity (0.31). In this case, the income per capita elasticity for the number of tourists is bigger, in absolute terms, than for total tourism expenditure. This difference indicates that an increase in real per capita income at the country of origin has a larger impact on the total number of tourist traveling to Mexico than on total tourism expenditure. The coefficients of the own-price elasticities (columns 1 and 2) are both smaller than unity in absolute terms[16]; however, the own-price elasticity of tourism expenditure (-0.94) is significantly larger than for the number of tourists (-0.39). This result suggests that a carbon tax might have a larger impact on total expenditure than on the number of tourists. Therefore, a CO_2 tax in Mexico would lead to a larger adjustment in total expenditure rather than travelers cancelling, postponing or changing their travel plans[17]. The cross-price elasticities are similar in both cases. These results are well within the range of international tourism elasticities reported by Witt and Witt (1995), Crouch (1996), and Peng et al. (2015) and they are also consistent with previous evidence for Mexico. Our results also highlight the relevance of differentiating between tourism expenditure and number of tourist for the analysis of the income and price elasticities. Finally, there are some differences between income per capita and price elasticities by country of origin, in particular for Canadian travelers.

The panel cointegration tests and panel cointegration equations in tables 5 and 6 indicate the existence of a long-run relationship on the demand for airplane tourism to Mexico, but do not indicate the direction of causality. Causality is usually tested using the standard Engle and Granger (1987) two-step procedure to determine short-run and long-run dynamics of the cointegrated relationship. For each cointegrated equation (te_{it} and tv_{it}) in table 6 we use the lagged residuals as the error correction term (ect_{-1}) in a dynamic error correction model based on Holtz-Eakin et al. (1988). We use the results of our preferred panel cointegration equations (DOLS panel regressions)[18] to estimate the following error correction specification.

(3a) $$\Delta te_{it} = \alpha_i + \sum_{k=1}^{q} \gamma_{1k} \Delta te_{it-k} + \sum_{k=0}^{q} \gamma_{2k} \Delta y_{it-k} + \sum_{k=0}^{q} \gamma_{3k} \Delta p_{it-k} + \sum_{k=0}^{q} \gamma_{4k} \Delta pa_{it-k} + \lambda ect_{-1} + v_{it}$$

[16] However, a T-test on the coefficient of the own-price elasticity of tourism expenditure (-0.94) suggests that this coefficient is not significantly different from unity (t-statistic = 0.41, prob. = 0.68).

[17] These price elasticities for expenditure and number of visitors are consistent with Crouch (1996). Wohlgemuth (1997) also finds high income elasticity and very low price elasticity for air travel.

[18] See table A2 of the appendix for the results of the Granger-casuality test using the FMOLS panel cointegration equation.

where Δ is the first-difference operator; q is the lag length set at two based on likelihood ratio tests; α_i represents country fixed effects and v is a serially uncorrelated error term. Since this is a dynamic panel data model standard estimation techniques yield biased and inconsistent estimators (Holtz-Eakin et al., 1988, 1989; Kiviet, 1995).To deal with this issue we follow authors such as Constantini and Martini (2010), Mandal and Madheswaran (2010), Al-Iriani (2006) and Christopoulos and Tsionas (2004) in using an instrumental variable (IV) estimator which yields consistent estimates of the parameters using lagged values of the dependent variable as instruments (Holtz-Eakin et al., 1988, 1989; Easterly et al., 1997). After estimating equations (3) the sources of causality can be identified by testing the significance of the coefficients of the independent variables. The sum of the lagged coefficients can be interpreted as the short-run elasticities and the coefficient on the error correction term represents the speed at which short-run deviations converge to the long-run equilibrium.

Table 7 shows the results of the dynamic error correction model for the demand of airplane tourism to Mexico on both, airplane tourism expenditure (te_{it}) and the number of airplane tourists (tv_{it}). The results of equation (3) shows that income per capita, local tourism prices at the destination country (Mexico) and the price level at the competitive destination (Colombia), each have a significant short-run effect on the demand for tourism to Mexico, both in terms of tourism expenditure and total tourist arrivals. The coefficients have the expected signs similar to the ones reported for the long-run relationships in table 6. When using tourism expenditure as the dependent variable the result show a short-run income per capita elasticity of 1.77, a negative short-run own-price elasticity of -0.98 and a positive short-run cross-price elasticity of 0.11. An examination of the sum lagged coefficients on the number of tourists suggest a short-run income per capita elasticity of 1.67, a negative short-run elasticity of -0.45 and a positive short-run cross-price elasticity of 0.13. In both cases, own-price short-run elasticities are similar to their long-run counterpart whereas cross-price elasticities are slightly lower in the short-run than in the long-run. For the case of tourism expenditure the short-run and long-run income per capita elasticities have similar values, whereas for the number of tourists the long-run elasticity is much higher than in the short-run. The negative and statistically significant coefficient on the error correction terms suggest that short-run deviations of the tourism demand to Mexico reverse to the long-run equilibrium in a relatively slow way.

Table 7. Error Correction Model of the demand of torusim to Mexico: using DOLS cointegration results on airplane tourism expenditure (Δte_{it}) and airplane tourists (Δtv_{it})

Dependent variable	Independent variables			
	Δy_{it-k}	Δp_{it-k}	Δpa_{it-k}	ect_{-1}
Δte_{it}	1.774*** (0.237) [55.79]	-0.981*** (0.106) [85.67]	0.109** (0.053) [4.260]	-0.164** (0.083)
Δtv_{it}	1.673*** (0.144) [134.8]	-0.449*** (0.123) [13.39]	0.127** (0.054) [5.631]	-0.388*** (0.127)

Note. The coefficients represent the sum of the lagged coefficients for the respective short-run parameters. Standard errors in parenthesis. The numbers in brackets represent the partial F-statistics reported with respect to short-run changes in the independent variable. (***), (**) and (*) indicates rejection of the null hypothesis at the 1%, 5% and 10% significance level, respectively. Unbalanced panel. Period 1980-2014 for *i* =United States and Canada, and 1980-2003 for *i* =Europe. All variables correspond to the first-difference of the natural logarithm of the series.

Once we have established a causal relationship between the variables considered in the cointegration equation, we estimate the potential long-run consequences of a CO_2 aviation tax on the demand for international tourism to Mexico. The methodology involves two steps. First, we estimate the percentage increase in the ticket cost associated with different scenarios of a carbon tax rate on aviation emissions. In doing so, we follow previous authors such as Olsthoorn (2001), Wit et al. (2002), Wit et al. (2005) and FitzGerald and Tol (2007), among others, in assuming that the tax is fully passed on to consumers. In reality, price elasticity of demand and supply and market structure determine how much of additional tax is passed on to consumers. For the tourism industry, Damonte et al. (1998) suggests that the more price inelastic the demand, the larger the proportion of the tax that is passed on to consumers and Anderson et al. (2001) argue that in an oligopolistic market, such as the airline industry, taxes might be passed on to consumers by more than 100 percent (Gabszewicz and Tarola, 2005). Given the price inelastic demand for the number of international tourists to Mexico (tv_{it}) in table 6 (-0,38), we believe that assuming the tax is fully passed on to consumers represents a valid assumption. For the second step of our estimation, we use the own- and cross-price elasticities from the cointegration equation in table 6 to estimate the potential effect of the carbon tax on tourist expenditure (te_{it}) and the number of tourists to Mexico (tv_{it}). This methodology is similar to Aguiló et al. (2005) and it has the obvious limitation that the tax is imposed on the value of airline tickets but it is evaluated on airplane tourism expenditure or the number of airplane tourists in the destination country. This implies that the different items of the budget for tourism expenditure have similar price responses.

The results for the percentage increase in the ticket cost due to the carbon tax are reported in table 8. In order to obtain these figures, we first estimate the average CO_2 emissions per passenger in a round-trip international flight to Mexico from the three countries of origin considered in the analysis (United States, Canada and Europe). Airplane carbon dioxide emissions can be estimated considering energy use, occupancy rates, type of plane, distance traveled and that takeoff and landing are energy intensive and therefore imply higher CO_2 emissions. For example, Wit et al. (2002) estimate 0.02 kg per passenger per kilometer and 6.5 kg per passenger for takeoff and landing.[19] Pearce and Pearce (2000) estimate that carbon dioxide emissions equal on average 4.05 kg C per passenger for takeoff and landing, and 0.013 kg per passenger-kilometer. Both estimations are relatively similar and are also similar to the ones available on the website www.climatecare.org. Based on this information, we estimate the implied CO_2 tax on airfare considering a range of three potential tax rates (10, 30 and 100 USD per tonne of CO_2). Finally, we compare the resulting monetary figure to the average economy cost of airline tickets to get an estimate of the percentage increase in the price of an airline ticket associated with each tax rate.

The estimations of the corresponding carbon tax on the price of the airline tickets appear in table 8. Monetary values are expressed in current US dollars. Information on the distance and airfare correspond to the average of a direct round trip to Mexico (Mexico City) from the country/region of origin considering the following cities: United States: Los Angeles and New York; Canada: Vancouver and Toronto; Europe: London, Madrid and Paris. Information on the cost of the airline tickets was accessed through www.skyscanner.net and corresponds to the average economy fare for a round trip between May-September 2016, as of February 2016. We estimate the values for the CO_2 emissions assuming traveling in an aircraft Boeing-747 type. The details of the calculations per city of origin are in table A1 of the appendix.

[19] There are differences in emissions between short, medium and long flights (Williams and Noland, 2006).

Table 8. Estimated increase in airplane ticket price due to carbon tax
(*round trip*)

Flying To: Mexico City, MEX		From United States	 Canada	 Europe	Average
Distance (kms)[1]		5,870	7,168	18,122	10,387
CO_2 emissions per passenger (tons)[3]		0.58	0.71	1.80	1.03
Economy class airfare (USD)[1, 2]		\$442	\$545	\$1,068	\$685
Carbon tax (per tonne of CO_2)[3]:					
10 USD	Implied tax on airfare	\$5.84	\$7.13	\$18.02	\$10.33
	Change in ticket cost	1.32%	1.31%	1.69%	1.51%
30 USD	Implied tax on airfare	\$17.51	\$21.38	\$54.05	\$30.98
	Change in ticket cost	3.96%	3.93%	5.06%	4.52%
100 USD	Implied tax on airfare	\$58.36	\$71.26	\$180.17	\$103.26
	Change in ticket cost	13.21%	13.09%	16.87%	15.07%

Note: [1] For each country/region it represents the average distance and airfare considering a round trip departing from the following cities: United States: Los Angeles and New York; Canada: Vancouver and Toronto; Europe: London, Madrid and Paris.
[2] Average economy cost of direct round trip ticket flying between May-September 2016, as of February 2016.
[3] Assumes traveling in a Boeing 747 with a fuel efficiency of 5 gallons per mile, emitting 9.6 kg of CO_2 per gallon of jet fuel, and an average of 300 passengers per aircraft. It is also assumed that the entire cost of the tax is passed on to consumers as an increase in the price of the ticket.

In this context a tax of 10 and 30 dollars per tonne of CO_2 implies a rise in the ticket price between 1.3 and 4.0% for travelers from United States, 1.3 and 3.9% for Canada and 1.7 and 5.1% for Europe. We use this information to estimate the overall long-term impact of the carbon tax on the demand of airplane tourism to Mexico using the average values of table 8 and the own- and cross-price elasticities from the cointegration equation of the DOLS panel specifications in table 6. The results appear in table 9.

Table 9 shows the potential effect of a carbon tax on the demand for airplane tourism to Mexico. Columns (1) and (3) show the direct effect of different carbon tax rates on tourist expenditure and the number of tourists, respectively. The results suggest that the average increase in the price of airline tickets due to the imposition of carbon tax of 10 and 30 dollars per tonne of CO_2 leads to a reduction in total tourism expenditure of 1.4 and 4.2%, and a reduction of 0.6 and 1.7% in the number of airplane tourists from United States, Canada and Europe. The results indicate that an airplane carbon tax on international tourism to Mexico has a large impact on the reduction of tourist expenditure rather than tourists cancelling or postponing their trip. These figures are calculated assuming that the relative tourist cost between Mexico and Colombia remains constant. Columns (2) and (4) show the additional reduction in the demand for tourism due to the change in relative prices between Mexico and the competitive destination, i.e. the substitution effect. Considering the substitution effect, the reduction in the number of tourists could go up to about 1 and 3% for the 10 and 30 dollars tax, respectively, for the year of the implementation (table 9). The last column in table 9 shows the potential fiscal revenues from each tax scenario. The results suggest that a tax of 10 and 30 dollars per tonne of CO_2 would lead to a total fiscal revenue between 163 and 480 million dollars in 2014. These estimations consider price and substitution effects and are estimated on the basis of a total number of airline tourists to Mexico of 13.5 million people for 2014[20].

Table 9. Estimated demand reduction and potential fiscal revenue due to carbon tax in the year of implementation

Carbon tax (per tonne of CO_2)	**Tourism expenditure (te_{it})** [1]			**Number of tourists (tv_{it})** [1]			**Potential fiscal revenue** [2] (million $USD)
	(1) Price effect (p_{it})	**(2) Substitution effect (pa_{it})**	**Total** (1)+(2)	**(3) Price effect (p_{it})**	**(4) Substitution effect (pa_{it})**	**Total** (3)+(4)	
10 USD	-1.42%	-0.52%	-1.94%	-0.58%	-0.47%	-1.05%	$163.5
30 USD	-4.25%	-1.56%	-5.81%	-1.74%	-1.39%	-3.13%	$480.2
100 USD	-14.17%	-5.21%	-19.38%	-5.82%	-4.67%	-10.49%	$1,403.2

Note: [1] Using the price elasticities of the DOLS panel specification in table 6.
[2] Calculated on the total number of airplane tourist to Mexico in 2014. Considers both, the price and substitution effect.

The carbon tax on international tourism demand in Mexico turns out to be an effective revenue-raising instrument and it is consistent with a continuous growth of the demand of international tourism. This is partly due to the inelastic demand of the number of international tourist traveling to Mexico. Only a CO_2 tax over 30 dollars per tonne might have a significant impact on the rate of growth of tourism expenditure on the year of implementation. For example, economic scenarios

[20] Data from the International travelers account reported by BANXICO.

for United States, Canada and Europe for the period 2015-2020[21] indicate that the average growth rates of tourism expenditure and the number of tourists[22] in Mexico, without any tax, will be 2.3% and 3.5%, respectively. Then, considering taxes of 10 and 30 dollars per tonne of CO_2, the average growth rates of tourism expenditure would be 2.0% and 1.6% respectively, and 3.4% and 3.2% for the number of tourists in the year of implementation. Also, the substitution effect of the alternative destination could further reduce the expected growth rates of tourism expenditure to 1.9% or 1.3% for the 10 and 30 dollars tax, respectively, and to 3.3% or 3.0% for the number of tourists for the year of implementation. Nevertheless, the evolution of airplane tourism demand will continue to grow at previous rates in the long run.

V. CONCLUSIONS

Airplane international tourism to Mexico shows a dynamic and continuous growth with a significant positive impact on the economy during the last two decades. However, it also has several negative externalities such as the emissions of greenhouse gases. In this sense, there is an increasing interest to consider the potential consequences of a CO_2 tax. This paper analyzes the potential consequences of a CO_2 tax on the evolution of airplane tourism expenditure and the number of airplane tourists in Mexico from United States, Canada and Europe considering the income and price elasticities.

The econometric evidence from a panel data indicates that international airline tourism expenditure in Mexico has a positive income per capita elasticity of 1.9 and a negative own price elasticity of -0.9. The number of international airline tourists shows an income per capita elasticity of 2.9 and an own price elasticity of -0.4. In both cases, the price elasticity of an alternative destination is 0.3. These results reveal important differences in the income and price elasticities between airplane tourism expenditure and number of airplane tourists. The price elasticities suggest larger

[21] Economic scenarios for GDP per capita of each country were constructed using official economic forecasts. For the United States the scenario of GDP growth is from the Federal Reserve Bank of St. Louis, and population growth from the US Census Bureau. For Canada the scenario on GDP growth is from the International Monetary Fund. (IMF) and population growth from official population statistics of the Government of Canada. For Europe GDP growth scenarios are from the IMF, and population scenarios from Eurostat.

[22] These results are estimated considering the aforementioned economic scenarios and the elasticities of the DOLS panel specifications in table 6.

adjustments in tourism expenditure than in trip decisions in the case of a new tax. This difference in price elasticities is relevant from a policy perspective. While the number of tourists to Mexico is unlikely to experience major changes as a result of a CO_2 aviation tax, incoming tourists are likely to adjust their spending on local consumption such as the length of the trip, the type of accommodation or other consumption goods at the destination country. The consequences of such changes for the Mexican economy remain an area of future research. The price elasticity of the competitive destination suggests the importance of considering a regional agreement for the implementation of international CO_2 aviation taxes. These results are consistent with the international evidence on the demand for tourism.

Overall, our results suggest that a CO_2 tax is consistent with a continuous growth on airplane international tourism demand to Mexico. That is, a tax of 10 dollars imply an average rise in the airline ticket price of 1.5% meanwhile a 30 dollars tax per tonne of CO_2 implies an average rise in the airline ticket price of 4.5%. In this context, the potential impact of carbon taxes of 10 and 30 dollars per tonne of CO_2 leads to a reduction in total airplane tourism expenditure of 1.4 and 4.4%, and a reduction of 0.6 and 1.7% in the number of airplane tourists from United States, Canada and Europe, respectively. These figures assume that the relative tourist cost between Mexico and a competitive destination remains constant. Estimations of a carbon tax of 10 and 30 dollars per tonne of CO_2 contribute to generate additional fiscal revenue for 163 and 480 million dollars, respectively. These results suggest that a carbon tax is therefore feasible and might also generate significant additional fiscal revenue but it is very important to consider the appropriate tax level and regional coordination.

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APPENDIX

Table A1. Estimated increase in airplane ticket price due to carbon tax, by city of origin
(*round trip*)

Flying To: Mexico City, MEX		**From**						
		United States		**Canada**		**Europe**		
		LA	**NY**	**VN**	**TR**	**LON**	**MAD**	**PAR**
Distance (kms)		5,004	6,736	7,894	6,442	17,816	18,142	18,410
Economy class airfare (USD)[1]		$335	$549	$575	$515	$918	$1,142	$1,144
Carbon Tax (per tonne of CO_2)[2]:								
10 USD	Implied tax on airfare	$4.97	$6.70	$7.85	$6.40	$17.71	$18.04	$18.30
	Change in ticket cost	1.49%	1.22%	1.37%	1.24%	1.93%	1.58%	1.60%
30 USD	Implied tax on airfare	$14.92	$20.09	$23.54	$19.21	$53.14	$54.11	$54.91
	Change in ticket cost	4.46%	3.66%	4.10%	3.73%	5.79%	4.74%	4.80%
100 USD	Implied tax on airfare	$49.75	$66.97	$78.48	$64.05	$177.13	$180.37	$183.03
	Change in ticket cost	14.86%	12.20%	13.66%	12.45%	19.29%	15.79%	15.99%

Note: LA=Los Angeles, NY=New York, VN=Vancouver, TR=Toronto, LON=London, MAD=Madrid, PAR=Paris.
[1] Average economy cost of direct round trip ticket flying between May-September 2016, as of February 2016.
[2] Assumes traveling in a Boeing 747 with a fuel efficiency of 5 gallons per mile, emitting 9.6 kg of CO_2 per gallon of jet fuel, and an average of 300 passengers per aircraft. It is also assumed that the entire cost of the tax is passed onto consumers as an increase in the price of the ticket.